# Update on SAO/LBNL/LLNL NTD Microcalorimeter Development for Constellation X

Constellation-X FST Meeting
October 14, 2004

Presented by:

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with input from:

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# Discussion Topics

1. Several Significant Technical Advances

These have led to:

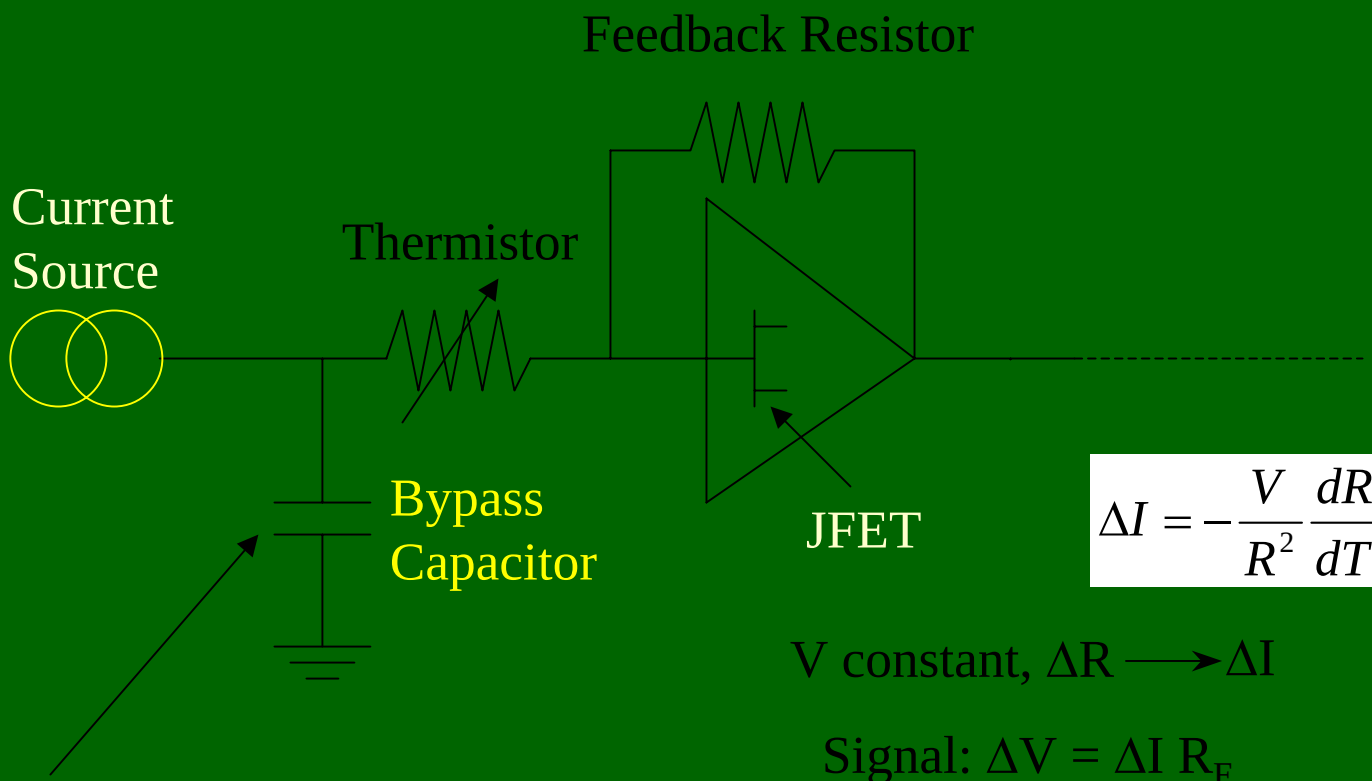
a reduction in low frequency (1/f) noise;
improved stability;
resolution performance of 3.08 eV at 6 keV.

This resolution is consistent with our theoretical model for *nominal detector parameters* which also predicts sub 2 eV at 1 keV.

New readout circuit promises further improvement

2. Progress has also been made in the design of a modular array technique that is readily expandable to the Constellation X 32 x 32 element array.

# Negative Voltage Feedback Preamplifier




$$\Delta I = -\frac{V}{R^2}\frac{dR}{dT}\Delta T$$

V constant, $\Delta R \longrightarrow \Delta I$

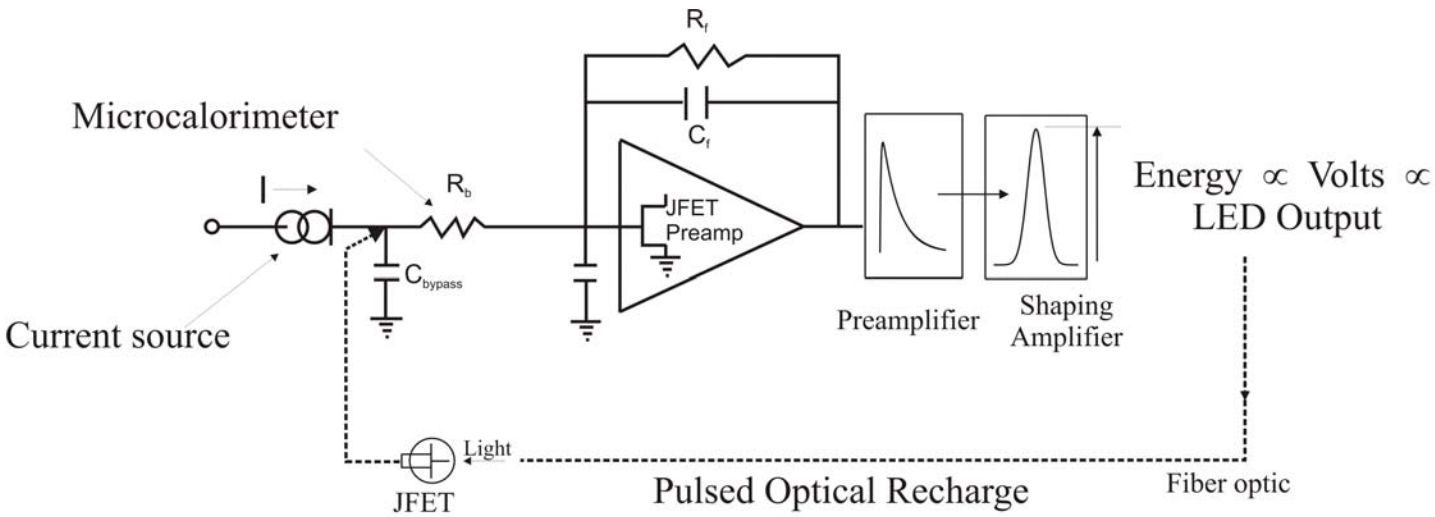
Signal: $\Delta V = \Delta I\ R_F$

Capacitor recharging: $\tau = RC_B$

# Noise measurements and JFET preamplifier stability

High open loop gain is essential for the operation of this configuration and requires substantial transconductance or gain, $g_m$, from the JFET;

$g_m$ is a strong function of the applied drain current ($g_m \triangle I_d$) while the noise, $V_n$, to first order, is proportional to $1/g_m^{1/2}$ (typically 0.5 - 1.5 nV/Hz ).

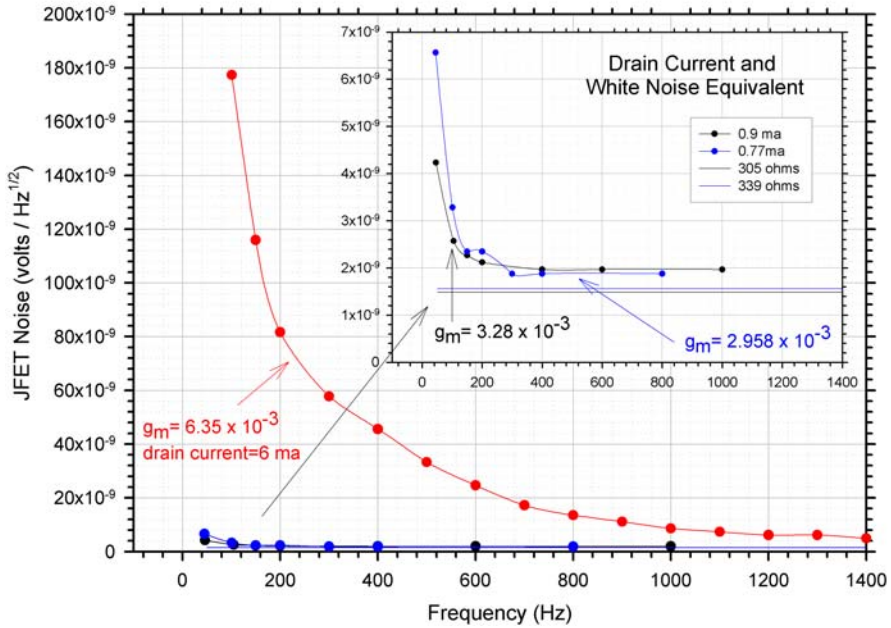


We suspected that the noise from the JFET was *excessive* at low frequencies;

We evaluated the noise contributions from the feedback resistor and the JFET ;

A special, AC grounded gate, preamplifier was built to measure the noise of the in-situ JFET independent of the feedback resistor;

By reducing the drain current below 1 mA, we significantly reduced the low frequency noise (1/f ) while incurring only a modest rise in high frequency noise.




**However,**

the JFET $g_m$ dropped a further factor of two when the drain current was reduced to the lower levels *consistent* with the desired low frequency, low noise operating point;

the open loop gain was also reduced a further factor of two. This reduction in open loop gain (originally 2000) caused us to reconsider the issue of virtual ground stability and dynamic impedance.

**Our solution:**

An entirely new preamplifier topology that has an open loop gain > 100,000 when the JFET is operated at a reduced drain current consistent with low noise at low frequencies;

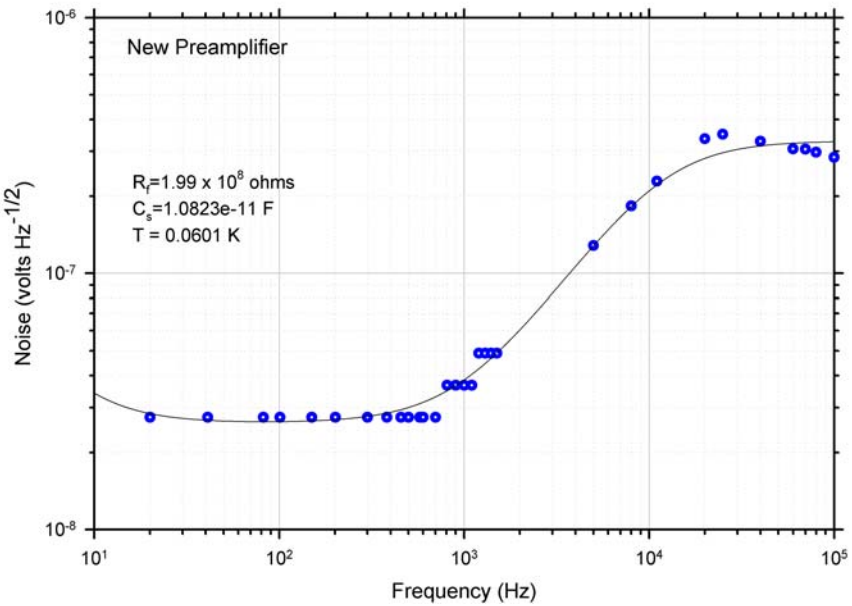
The issues of virtual ground dynamic impedance and stability are gone;

Serendipitously, the power requirements are less and there are fewer components.

An additional set of measurements was performed to verify that the combined noise from the JFET and feedback resistor was what one expected from theoretical predictions;

The results show that the circuitry is well understood;

There was an immediate improvement in the performance;



SAO

# NTD Germanium Microcalorimeter Resolution Performance

Improved understanding of signal and noise

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Modified preamplifier topology

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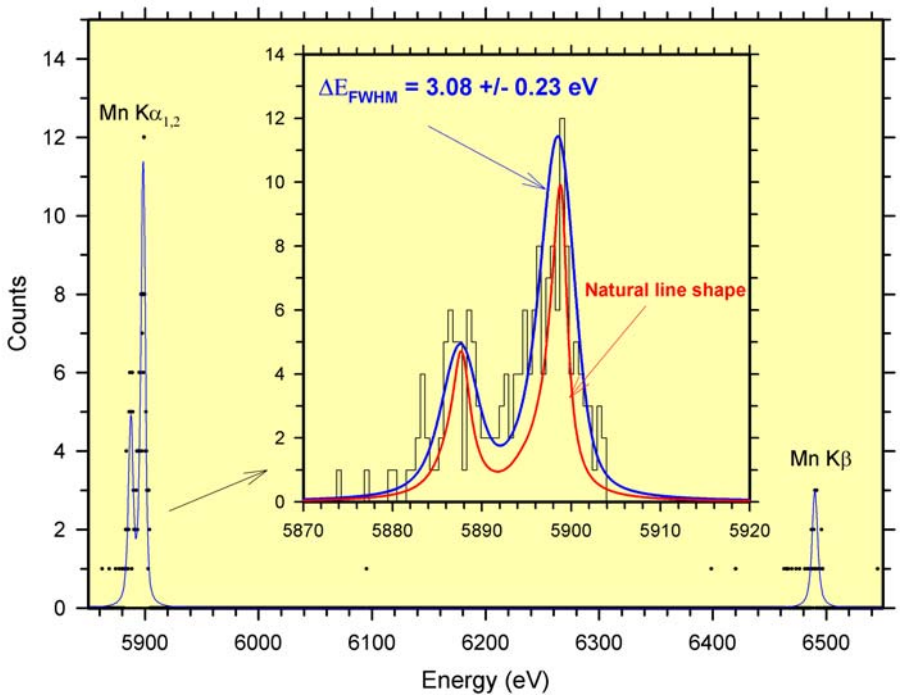
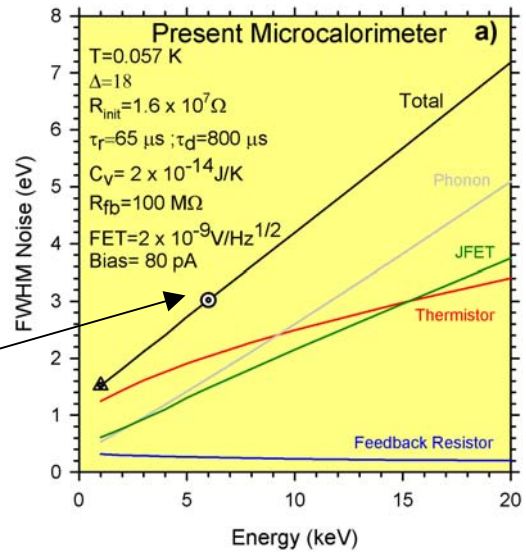
**3.08 eV at 6 keV**

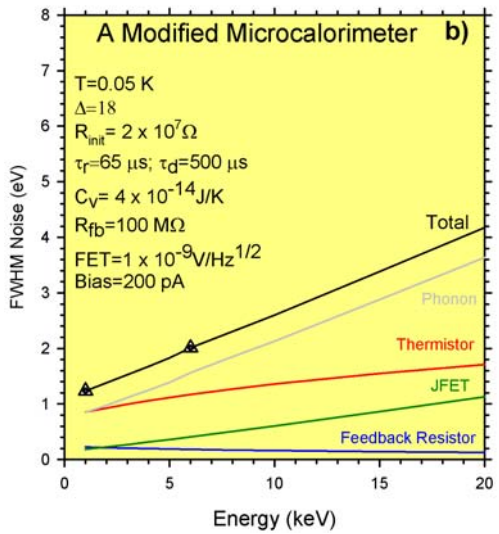
↓

Consistent with theoretical modeling



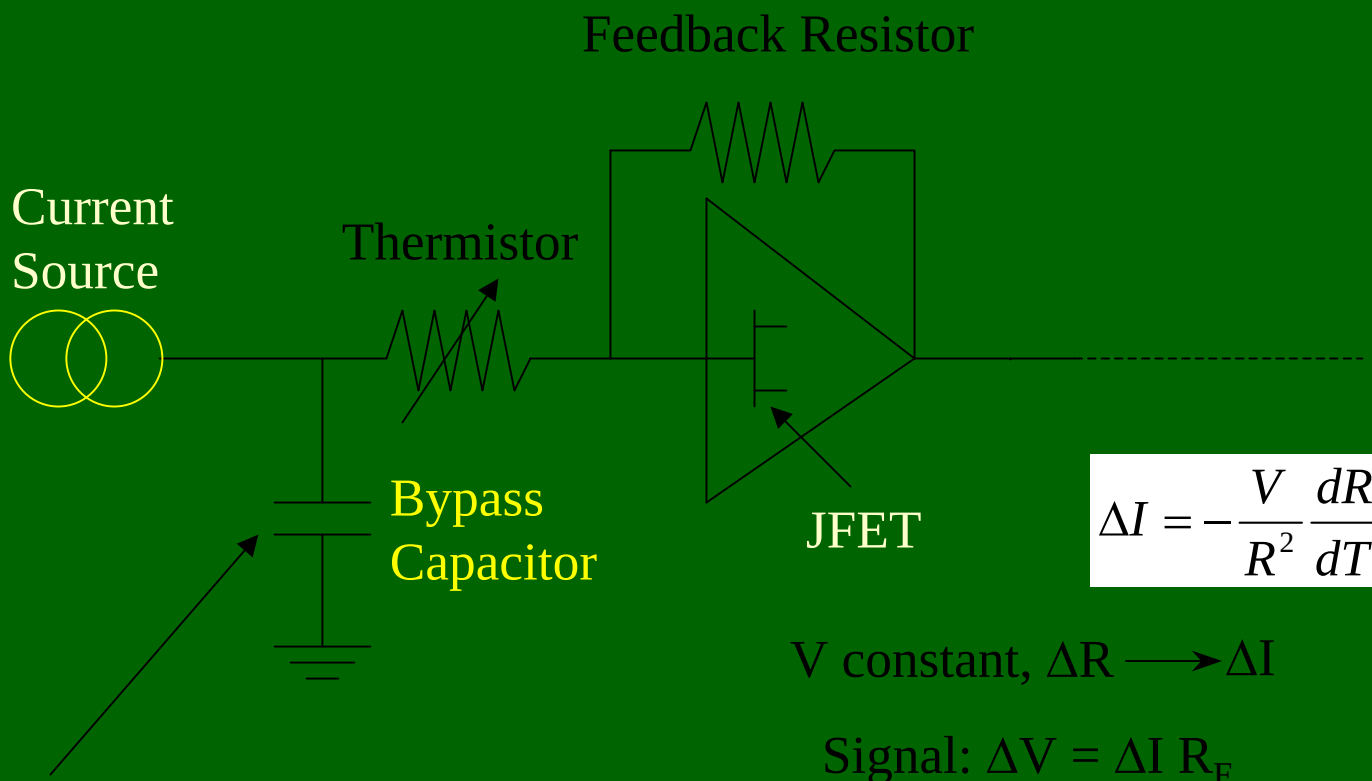

## Theoretical Model Predictions




0.35 mm x 0.35 mm x 7 μm tin absorber + NTD 17 Ge thermistor

# Negative Voltage Feedback Preamplifier

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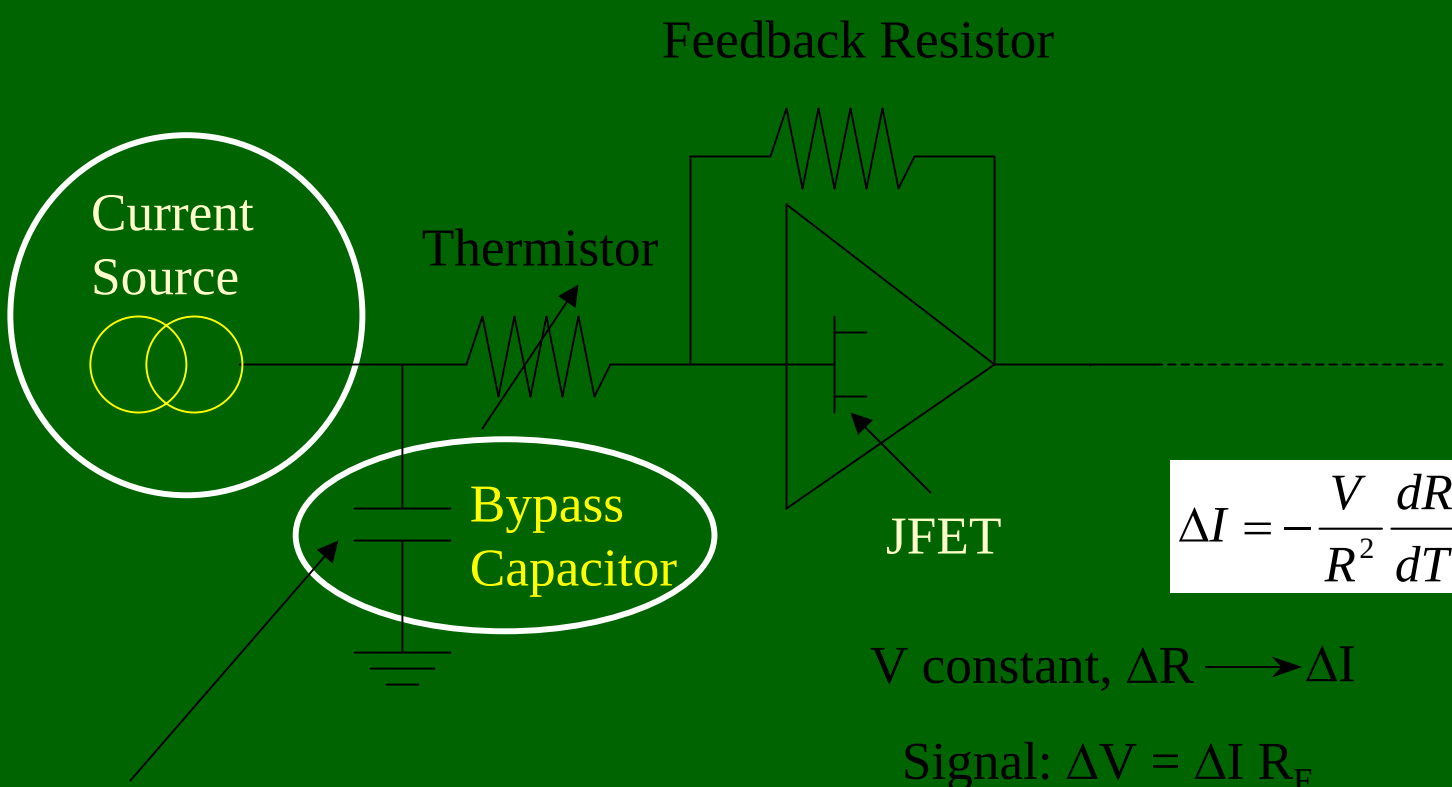


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Pulsed optical recharge

# New Negative Voltage Feedback Preamplifier

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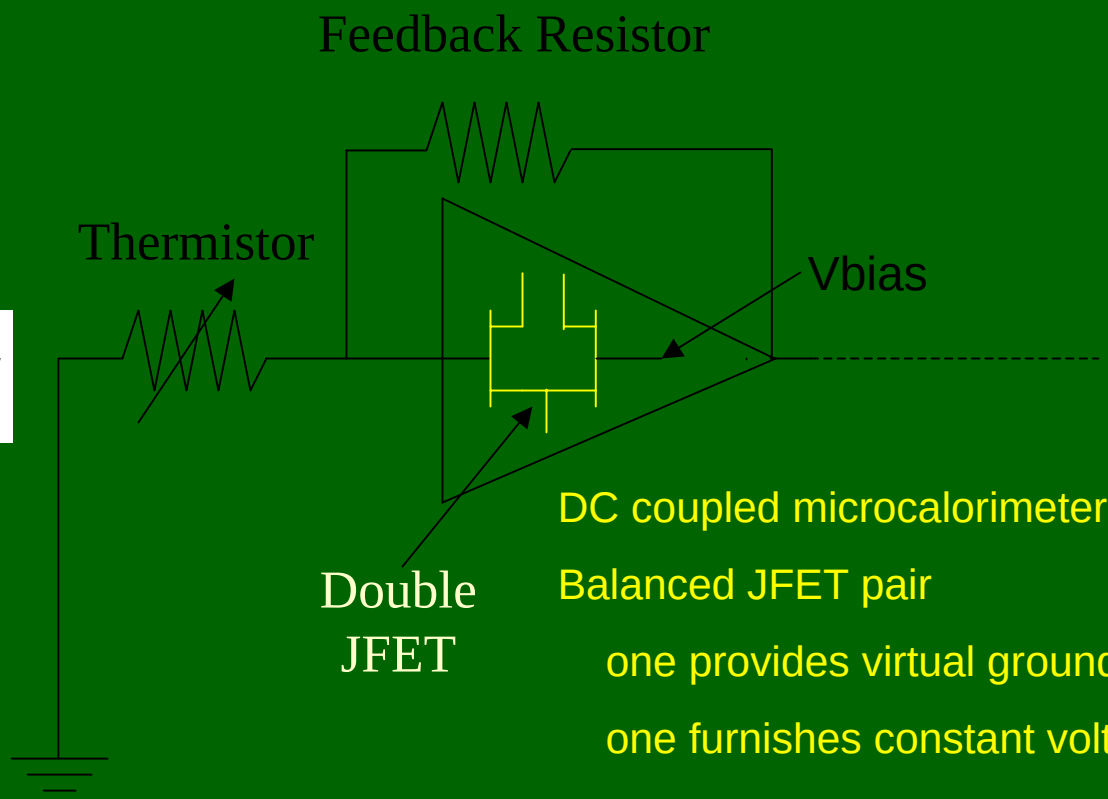



DC coupled microcalorimeter

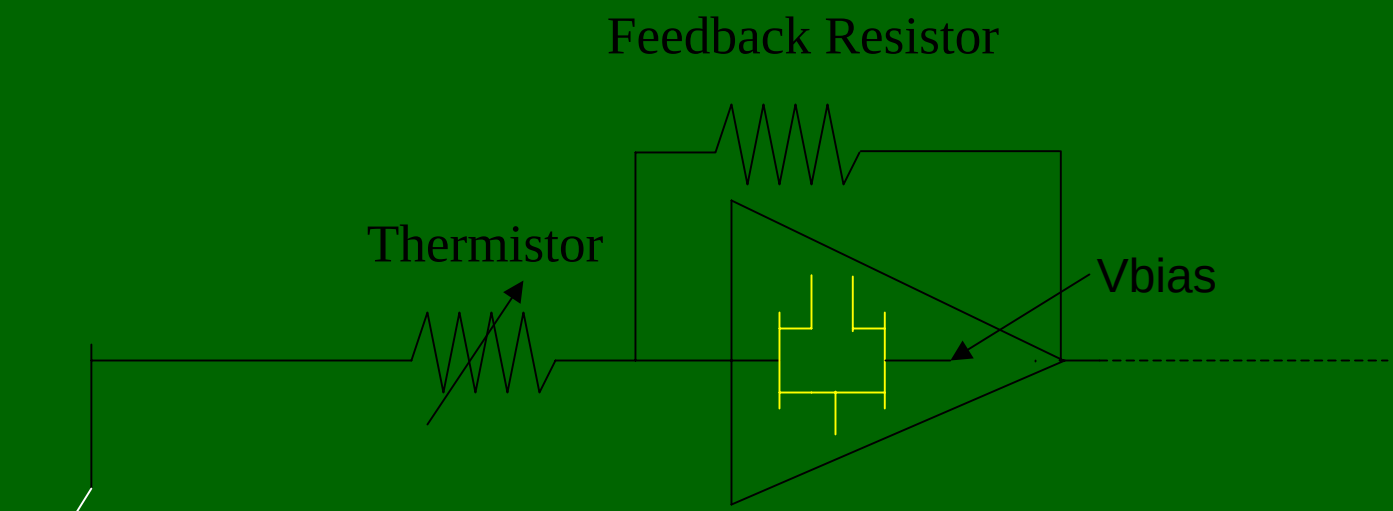
Balanced JFET pair

- one provides virtual ground
- one furnishes constant voltage bias

No recharging time!

Microcalorimeter ready for second event as soon as temperature returns to quiescent operating point

# New Negative Voltage Feedback Preamplifier




Higher count rates without spectral smearing

Easier to implement temperature resetting

The voltage bias set by circuitry of the second JFET has intrinsically fewer pitfalls,

a stable, relatively noise-free voltage source (of a few millivolts) is much easier to produce than a stable, relatively noise free current of $10^{-10}$ amps

Since the microcalorimeter bias is now a true voltage and not a very small current, the potential for current-robbing leakage paths in cryostat feedthroughs is also eliminated

# Modular Construction of NTD Ge Microcalorimeter Array for Constellation X

Each linear array module is fitted with a miniature connector attached to the bottom of the sapphire substrate through which the electrical signals are fed .

Each module is inserted into a mating connector mounted into a *quadrant base*. A two-dimensional array can be built up from a series of these stacked linear arrays. constructed in this way also